Identification of Extremely Premature Infants at High Risk of Rehospitalization

WHAT'S KNOWN ON THIS SUBJECT: Extremely low birth weight infants are at high risk of rehospitalization in infancy, often for respiratory illnesses. Few studies have evaluated which prematurely born infants will need rehospitalization or will have persistent respiratory problems after discharge.

WHAT THIS STUDY ADDS: Scoring systems and classification and regression-tree analysis models were developed to identify extremely low birth weight infants at higher risk of rehospitalization and might help target interventions to infants at higher risk and assist in planning quality improvement initiatives.

abstract

OBJECTIVE: Extremely low birth weight infants often require rehospitalization during infancy. Our objective was to identify at the time of discharge which extremely low birth weight infants are at higher risk for rehospitalization.

METHODS: Data from extremely low birth weight infants in Eunice Kennedy Shriver National Institute of Child Health and Human Development Neonatal Research Network centers from 2002–2005 were analyzed. The primary outcome was rehospitalization by the 18- to 22-month follow-up, and secondary outcome was rehospitalization for respiratory causes in the first year. Using variables and odds ratios identified by stepwise logistic regression, scoring systems were developed with scores proportional to odds ratios. Classification and regression-tree analysis was performed by recursive partitioning and automatic selection of optimal cutoff points of variables.

RESULTS: A total of 3787 infants were evaluated (mean $\pm$ SD birth weight: 787 $\pm$ 136 g; gestational age: 26 $\pm$ 2 weeks; 48% male, 42% black). Forty-five percent of the infants were rehospitalized by 18 to 22 months; 14.7% were rehospitalized for respiratory causes in the first year. Both regression models (area under the curve: 0.63) and classification and regression-tree models (mean misclassification rate: 40%–42%) were moderately accurate. Predictors for the primary outcome by regression were shunt surgery for hydrocephalus, hospital stay of >120 days for pulmonary reasons, necrotizing enterocolitis stage II or higher or spontaneous gastrointestinal perforation, higher fraction of inspired oxygen at 36 weeks, and male gender. By classification and regression-tree analysis, infants with hospital stays of >120 days for pulmonary reasons had a 66% rehospitalization rate compared with 42% without such a stay.

CONCLUSIONS: The scoring systems and classification and regression-tree analysis models identified infants at higher risk of rehospitalization and might assist planning for care after discharge. *Pediatrics* 2011;128:e1216–e1225

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KEY WORDS

logistic models, infant, premature, predictive value of tests

ABBREVIATIONS

ELBW—extremely low birth weight
BPD—bronchopulmonary dysplasia
CART—classification and regression tree
NICHD—Eunice Kennedy Shriver National Institute of Child Health and Human Development
NRN—Neonatal Research Network
ROC—receiver operating characteristic
FIO_2—fraction of inspired oxygen
OR—odds ratio
CI—confidence interval
DCC—data coordinating center

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Extremely low birth weight (ELBW) infants are at high risk of rehospitalization in infancy, often for respiratory illnesses.[1–5] These rehospitalizations are accompanied by significant morbidity and sometimes mortality[4,5] and occur at high cost to the family as well as society.[4,6] Strategies such as the use of prophylaxis for respiratory syncytial virus infections[7] and comprehensive follow-up care[8] are designed to reduce these rehospitalizations. Few studies have evaluated models to predict which prematurely born infants will need rehospitalization or will have persistent respiratory problems after discharge from the hospital. Although infants with bronchopulmonary dysplasia (BPD) are generally at higher risk for adverse respiratory outcome,[3,4] BPD occurs along a spectrum of severity, and a diagnosis of BPD is not sufficiently specific or sensitive to identify infants who will require rehospitalization.

We developed and evaluated scoring systems and classification and regression-tree (CART) models to identify infants at the time of NICU discharge who are at higher risk for all rehospitalization before the 18- to 22-month follow-up visit and rehospitalization that results from respiratory causes in the first year. An objective estimate of the risk of rehospitalization might help targeting interventions to infants at higher risk and might also assist in planning quality improvement initiatives.

METHODS

This study was a retrospective analysis of prospective ongoing data collection (the Generic Database) and newborn follow-up performed in the 17 participating tertiary academic centers of the Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD) Neonatal Research Network (NRN) from 2002 to 2005.[9] Infants who weighed 401 to 1000 g at birth of both genders and all racial/ethnic groups were evaluated. The data analyzed are collected systematically, stored in a database, and used for the surveillance of the care and outcome of high-risk infants in NICUs and in planning prospective clinical trials. The identity of the patients is kept confidential. Data collection for the NRN Generic Database was approved by the institutional review boards of the participating institutions, and parental consent was obtained for follow-up visits.

A comprehensive history, physical examination, and neurodevelopmental assessment were performed by trained and certified personnel during the follow-up visit at 18- to 22-months adjusted age.[10] Rehospitalization for any cause before the 18- to 22-month follow-up visit was the primary outcome, and rehospitalization for respiratory causes before the first birthday was the secondary outcome. Rehospitalization was defined as at least 1 overnight stay in a hospital since initial discharge from the hospital or to a chronic care facility. This secondary outcome was chosen because preliminary analysis indicated that two-thirds of rehospitalizations for respiratory causes are in the first year, and respiratory illnesses account for the majority of the rehospitalizations in the first year. These outcomes were obtained from the follow-up records using the comprehensive history recorded on the data collection forms.

Variables Used for Model Development

A combination of maternal variables, neonatal variables at birth, neonatal clinical variables including respiratory support variables, and discharge environment variables were evaluated for inclusion in the models (Table 1).

Development of Scoring Systems on the Basis of Regression Analysis

Because odds ratios (ORs) and coefficients from regression analysis are not sufficient by themselves to enable clinicians to quantitatively estimate risk, logistic regression was used to develop scoring systems using techniques as previously described.[11] The scoring systems provide a numeric value, which indicates the magnitude of risk (a higher score indicating a higher risk). Variables associated with outcome in unadjusted bivariate analyses were selected by using a backward elimination logistic regression model in which the least significant variable was removed at each step until all remaining variables were significant at a P value of $<.2$. Then, a best subset selection process was used to identify the 5 variables most strongly associated with outcome based on their contribution to R^2 to limit the effect of statistically significant variables that contributed little to predictive ability. These 5 variables were used to construct the final logistic regression model. The ORs from this model were converted into point totals >1 by dividing each respective OR by the smallest OR for any given level of a variable. Next, an overall score was computed for each infant by summing the points they received for each variable in the model. Continuous variables were divided into 3 categories by developing a receiver operating characteristic (ROC) curve for that variable with regard to the outcome (unadjusted for other predictors), and identifying the cutoff points for 80% sensitivity and 80% specificity. Separate models were developed for primary and secondary outcomes.

CART Analysis

CART models were created by using CART 6.0 (Salford Systems, San Di-

TABLE 1 Patient Characteristics and Variables Evaluated for Inclusion in Models

	Rehospitalized Infants by 18–22 mo (n = 1722)	Infants Not Rehospitalized (n = 2065)	P[a]
Maternal variables			
Mother's age, mean ± SD, y	26.9 ± 6.5	27.7 ± 6.6	.0004
Marital status (married), %	45	51	.0002
Education (high school or less), %	61	57	.03
Medical insurance (private), %	29	35	.0002
Hypertension (present), %	27	33	<.0001
Antenatal steroids (any given), %	81	83	.11
Maternal antibiotics given within 72 h of delivery, %	66	65	.47
Cesarean delivery, %	64	70	<.0001
Neonatal variables at birth			
Outborn infant, %	10	8	.07
Male gender, %	53	43	<.0001
Black, %	43	41	.35
Gestational age, mean ± SD, completed wk	25.9 ± 1.9	26.3 ± 1.9	<.0001
Apgar score at 1 min			
Median (25th–75th percentiles)	5 (3–7)	5 (3–7)	.02[b]
Mean ± SD	4.6 ± 2.4	4.8 ± 2.5	.04
Apgar score at 5 min			
Median (25th–75th percentiles)	7 (6–8)	7 (6–8)	.002[b]
Mean ± SD	6.7 ± 1.9	6.9 ± 1.9	.003
Apgar score at 1 min <4 (%)	35	33	.35
Apgar score at 5 min <4 (%)	8	7	.53
Bag and mask ventilation at birth, %	82	81	.38
Intubation at birth, %	75	71	.003
Birth weight, g	773 ± 137	799 ± 134	<.0001
Neonatal variables, in hospital			
Weight at 36 wk PMA, g	2587 ± 593	2526 ± 558	.001
Length at 36 wk PMA, cm	45 ± 3.3	44.9 ± 3.0	.57
Respiratory distress syndrome, %	96	95	.31
No. of surfactant doses			.0002
None	17	20	
1	40	43	
>1	43	37	
Postnatal steroids for BPD, %	18	11	<.0001
PDA, %	50	46	.02
PDA, indomethacin, %	40	37	.06
PDA, surgery, %	20	13	<.0001
Indomethacin at <24 h, %	41	40	.33
Severe IVH, %	16	11	<.0001
PVL, %	6	4	.07
Shunt for hydrocephalus, %	5	1	<.0001
Proven NEC or spontaneous gastrointestinal perforation, %	15	8	<.0001
Duration of TPN, d			<.0001
Mean ± SD	37.9 ± 25.9	30.1 ± 20.5	
Median (25th–75th percentiles)	30.5 (19–49)	25 (16–38)	
Blood culture negative for clinical sepsis (No. of episodes)			<.0001
Mean ± SD	0.96 ± 1.21	0.69 ± 1.00	
Median (25th–75th percentiles)	1 (0–2)	0 (0–1)	
Blood culture positive for sepsis (No. of episodes)			<.0001
Mean ± SD	0.67 ± 1.00	0.51 ± 0.84	
Median (25th–75th percentiles)	0 (0–1)	0 (0–1)	
Hearing loss, %	19	15	.002
ROP stage ≥3 disease, %	31	21	<.0001
Discharged from hospital on continuous oxygen at <120 d, %	17	14	<.05
Discharged from hospital on diuretics at <120 d, %	10	10	.38
Discharged from hospital on bronchodilators at <120 d, %	4	3	.02
Infant in hospital for >120 d for pulmonary causes, %	22	10	<.0001
Discharged from hospital on continuous oxygen at >120 d, %	14	5	<.0001
Discharged from hospital on diuretics at >120 d, %	12	5	<.0001
Discharged from hospital on bronchodilators at >120 d, %	8	3	<.0001

TABLE 1 Continued

	Rehospitalized Infants by 18–22 mo (n = 1722)	Infants Not Rehospitalized (n = 2065)	P^a
Neonatal variables, respiratory support			
Physiologic BPD, %	49	34	<.0001
FIO_2 at 36 wk PMA	0.31 ± 0.18	0.26 ± 0.14	<.0001
Duration of conventional ventilation by 36 wk PMA, d			<.0001
Mean ± SD	25.1 ± 21.8	18.0 ± 18.6	
Median (range)	22 (0–88)	12 (0-91)	
Duration of high-frequency ventilation by 36 wk PMA, d			<.0001
Mean ± SD	4.4 ± 9.1	2.9 ± 7.3	
Median (range)	0 (0–70)	0 (0–60)	
Total duration of conventional or high-frequency ventilation, d			<.0001
Mean ± SD	29.5 ± 24.6	20.9 ± 21.2	
Median (range)	26 (6–48)	14 (2–34)	
Duration of nasal SIMV by 36 wk PMA, d			.16
Mean ± SD	1.8 ± 5.0	1.6 ± 4.6	
Median (range)	0 (0–35)	0 (0–38)	
Duration of CPAP by 36 wk PMA, d			.96
Mean ± SD	12.6 ± 12.2	12.6 ± 12.2	
Median (range)	9 (0–69)	9 (0–79)	
Duration of supplemental O_2 by 36 wk PMA, d			<.0001
Mean ± SD	55 ± 25	47 ± 26	
Median (range)	62 (0–96)	53 (0–95)	
Neonatal variables, discharge environment			
No. of people living in infant's household			.005
Mean ± SD	4.4 ± 1.6	4.3 ± 1.6	
Median	4	4	
No. of biological siblings <3 y in infant's household			.65
Mean ± SD	1.38 ± 0.7	1.39 ± 0.7	
Median	1	1	

Continuous variables in mean ± SEM; categorical variables in %. PMA indicates postmenstrual age; PDA, patent ductus arteriosus; IVH, intraventricular hemorrhage; PVL, periventricular leukomalacia; NEC, necrotizing enterocolitis; TPN, total parenteral nutrition; SIMV, synchronized intermittent mechanical ventilation; CPAP, continuous positive airway pressure.
[a] P values are from Fisher's exact test for categorical variables or unadjusted linear regression (1-way analysis of variance) for continuous variables. For Apgar scores, P values are shown from nonparametric median test in addition to 1-way analysis of variance.

ego, CA) to perform recursive partitioning and automatic selection of optimal cutoff points of variables as previously described.[11,12] CART analysis generates a classification tree with a series of binary splits.[13,14] When CART analysis is performed on a population with cases and controls, each binary split in a classification tree yields 2 subgroups, 1 with a higher proportion of cases and the other with a higher proportion of controls.[13,14] These classification trees are therefore useful for classifying subjects according to the probability of being a case. The more important a variable in relation to outcome, the higher it is on the decision tree, and this facilitates the identification of the relative importance of variables.

RESULTS

Patient Characteristics

From the population of 4225 ELBW infants who survived to the 18- to 22-month follow-up, 3787 infants (90%) were evaluated (mean ± SD birth weight: 787 ± 136 g; gestational age: 26 ± 2 weeks; 48% male, 42% black). Data on rehospitalization were missing for the remaining 438 (10%) of the infants, who had a similar gender distribution but were slightly heavier and more mature (birth weight: 801 ± 142 g; gestational age: 26.4 ± 2 weeks; $P < .05$) when compared with infants with available rehospitalization data. Forty-five percent of the infants were rehospitalized by the 18- to 22-month follow-up, and 14.7% were rehospitalized for respiratory causes in the first year. Patient characteristics and unadjusted comparisons for the primary outcome are shown in Table 1.

Rehospitalizations by the 18- to 22-Month Follow-up

The reasons for rehospitalization before the 18- to 22-month follow-up were: respiratory (45.4%), surgery (20.5%), infection (16%), growth and nutrition (4.6%), central nervous system (4.2%), apnea (1.4%), trauma (1.2%), reflux (1.1%), apparent life-threatening event (0.4%), environmental (0.2%), and other (5.1%). The causes for rehospitalization in the first year were: respiratory (43.7%), surgery (22.9%), infection (15.2%), central nervous system (4.2%), growth and nutrition (3.9%), apnea (1.9%), reflux (1.5%), trauma (1.1%), environmental (0.1%), and other (5.1%).

TABLE 2 Scoring System for Rehospitalization by 18- to 22-Month Follow-up

Variable	Level of Variable	OR (95% Confidence)	Score
Shunt for hydrocephalus	No	0.22 (0.13–0.37)	1.0
	Yes	—	4.5
Infant in hospital >120 d due to pulmonary reasons	No	0.52 (0.42–0.64)	1.0
	Yes	—	1.9
Proven necrotizing enterocolitis or spontaneous gastrointestinal perforation	No	0.65 (0.52–0.80)	1.0
	Yes	—	1.6
$\mathrm{FiO_2}$ at 36 wk	0.21	0.63 (0.52–0.76)	1.0
	0.21–0.28	0.83 (0.59–1.16)	1.3
	>0.28	—	1.6
Gender	Female	0.75 (0.65–0.86)	1.0
	Male	—	1.3

Total score[a]	Sensitivity	Specificity	PPV	NPV	Outcome Present (*n*)	Outcome Absent (*n*)
>5.0	100	0	46	0	1585	1840
>5.3	75	40	52	65	1189	1096
>5.6	42	79	63	61	661	386
>8.5	5	99	80	55	80	20

$N = 3425$ (1585 rehospitalized); 362 infants deleted from the 3787 evaluated infants due to missing values (360 missing $\mathrm{FiO_2}$ data, 2 infants missing shunt data). PPV indicates positive predictive value; NPV, negative predictive value.
Range of score: 5–10.9.
0.63; $R^2 = 0.059$; maximum rescaled $R^2 = 0.079$.
Hosmer and Lemeshow goodness-of-fit test: $P = .16$.
[a] The total score is obtained by adding the scores for each of the variables. Shown in the lower half of the table is the interpretation of total score.

For the primary outcome of all rehospitalizations before the follow-up visit, the predictors were shunt surgery for hydrocephalus, hospital stay for >120 days for pulmonary reasons, necrotizing enterocolitis or spontaneous gastrointestinal perforation, higher fraction of inspired oxygen ($\mathrm{FiO_2}$) at 36 weeks, and male gender (Table 2). The scoring system had only moderate accuracy as the area under the ROC curve was 0.63. The minimum score was 5, and the maximum possible score was 10.9.

Using CART analysis (Fig 1), infants with hospital stays >120 days for pulmonary reasons had a 66% rehospitalization rate versus 42% for those discharged before 120 days (79% if shunt surgery was done for hydrocephalus versus 41% if not). The overall misclassification rate was 0.40.

Rehospitalization in the First Year for Respiratory Causes

Using regression analysis, rehospitalization in the first year for respiratory causes was predicted by discharge on bronchodilators, hospital stay of >120 days for pulmonary reasons, more episodes of late-onset culture-negative infection treated with antibiotics >5 days, nonprivate insurance, and male gender (Table 3). The area under the ROC curve was 0.63. The scoring system had a minimum score of 5 and a maximum possible score of 7.8.

By CART analysis (Fig 2), infants mechanically ventilated for ≥22 days had a 19% respiratory rehospitalization rate (24% if $\mathrm{FiO_2}$ at 36 weeks >0.25 while on intermittent mandatory ventilation/continuous positive airway pressure/oxygen hood versus 16% if $\mathrm{FiO_2}$ was lower) versus 11% in those ventilated for a shorter duration. In the latter group, infants with a hospital stay of >120 days for pulmonary reasons had a 38% respiratory rehospitalization rate versus only 11% without such a stay. The overall misclassification rate was 0.42.

DISCUSSION

The scoring systems and the CART models identified infants at higher risk of rehospitalization. This information on the risk of rehospitalization might assist parents and health care providers in planning care after discharge.

Innovative aspects of this study include the development of scoring systems using regression analysis and the development of CART models. Scoring systems enable estimation of the magnitude of risk for an individual in a user-friendly manner compared with regression equations or resulting ORs from which a precise or accurate measure of risk is difficult to determine. Although the CART method for constructing the models might be complex, the resulting decision trees are simple to use and are similar to algorithms used in most clinical guidelines. CART analysis is useful at identification of optimal cutoff points in continuous variables and in ranking the variables according to order of importance, such that more important variables are ranked higher on the classification tree. This type of analysis is intuitive for clinicians who are used to following decision trees.

The scoring system using regression analysis and the CART model for over-

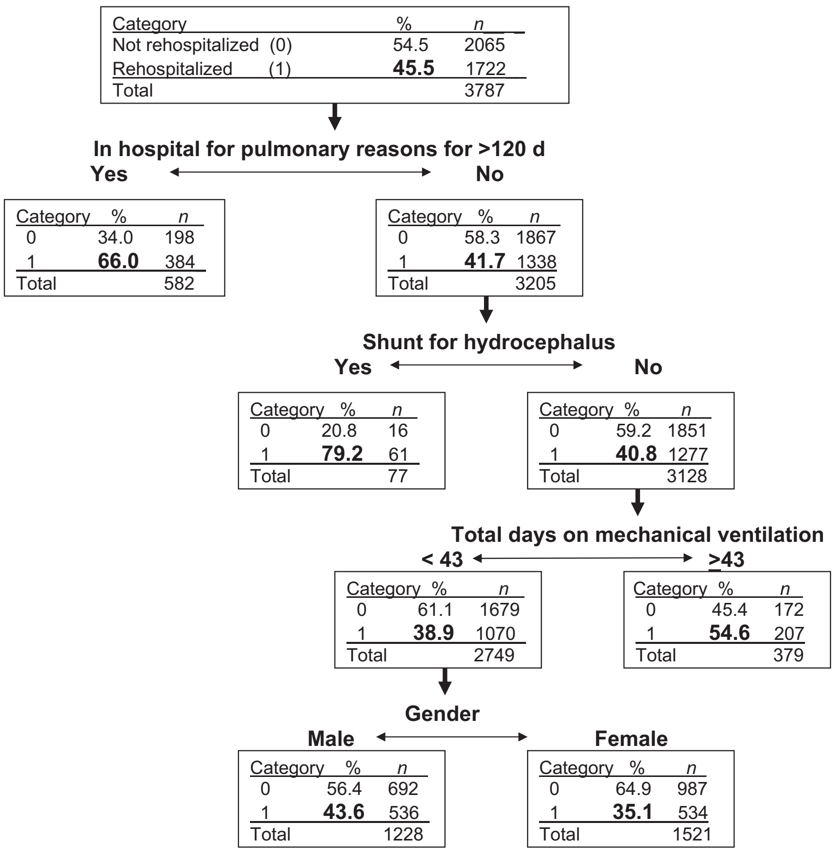

FIGURE 1
CART model for rehospitalizations by the 18- to 22-month follow-up. In each node (rectangle), the category "0" or "1" refers to the absence or presence of rehospitalization, respectively, and the percentages and *n* values refer to the infants in each of the categories.

all rehospitalization by 18 to 22 months provide complementary information and useful insight into the reasons for rehospitalization. For example, infants who were shunted for hydrocephalus were at much higher risk for rehospitalization according to both models (probably because shunt complications and need for revision are not uncommon and might lead to readmissions[15,16]), but the number of infants who were shunted is a relatively small fraction of all ELBW infants, and hospitalization for >120 days for pulmonary reasons, which includes many more infants, is higher on the CART model. However, the magnitude of risk caused by prolonged hospitalization for an individual infant is smaller than that associated with a shunt, as indicated both by a smaller score in the scoring system and a smaller proportion of rehospitalized infants in the CART model. Other variables such as proven necrotizing enterocolitis or spontaneous gastrointestinal perforation (scoring system), F_{IO_2} at 36 weeks (scoring sys-

TABLE 3 Scoring System for Rehospitalization for Respiratory Causes in First Year

	Level of Variable	OR (95% Confidence Interval)	Score
Discharge on bronchodilators	No	0.39 (0.26–0.56)	1.0
	Yes	—	2.6
Infant in hospital >120 d due to pulmonary reasons	No	0.53 (0.41–0.68)	1.0
	Yes	—	1.9
Insurance	Private	0.66 (0.53–0.82)	1.0
	Other	—	1.5
Episodes of late-onset culture-negative infection treated with antibiotics for >5 d	0	0.69 (0.54–0.89)	1.0
	1	0.88 (0.67–1.15)	1.3
	>1	—	1.4
Gender	Female	0.77 (0.64–0.94)	1.0
	Male	—	1.3

Total score[a]	Sensitivity	Specificity	PPV	NPV	Outcome Present (*n*)	Outcome Absent (*n*)
>5.0	100	0	15	0	503	2935
>5.5	86	23 16		91	434	2263
>6.0	45	74 23		89	228	762
>6.5	25	88 26		87	127	360

N = 3438 (503 rehospitalized in first year for respiratory causes); 349 infants deleted from the 3787 evaluated infants because of missing values (347 missing data on cause and/or timing of rehospitalization, 2 infants missing data on late-onset culture-negative infection). PPV indicates positive predictive value; NPV, negative predictive value. Predictor variables, OR, and the score assigned to each variable are shown.
Actual range of scores: 5–8.7.
0.63; $R^2 = 0.026$; max-rescaled $R^2 = 0.045$.
Hosmer and Lemeshow Goodness-of-Fit test: $P = .35$.
[a] The total score is obtained by adding the scores for each of the variables. Shown in the lower half of the table is the interpretation of total score.

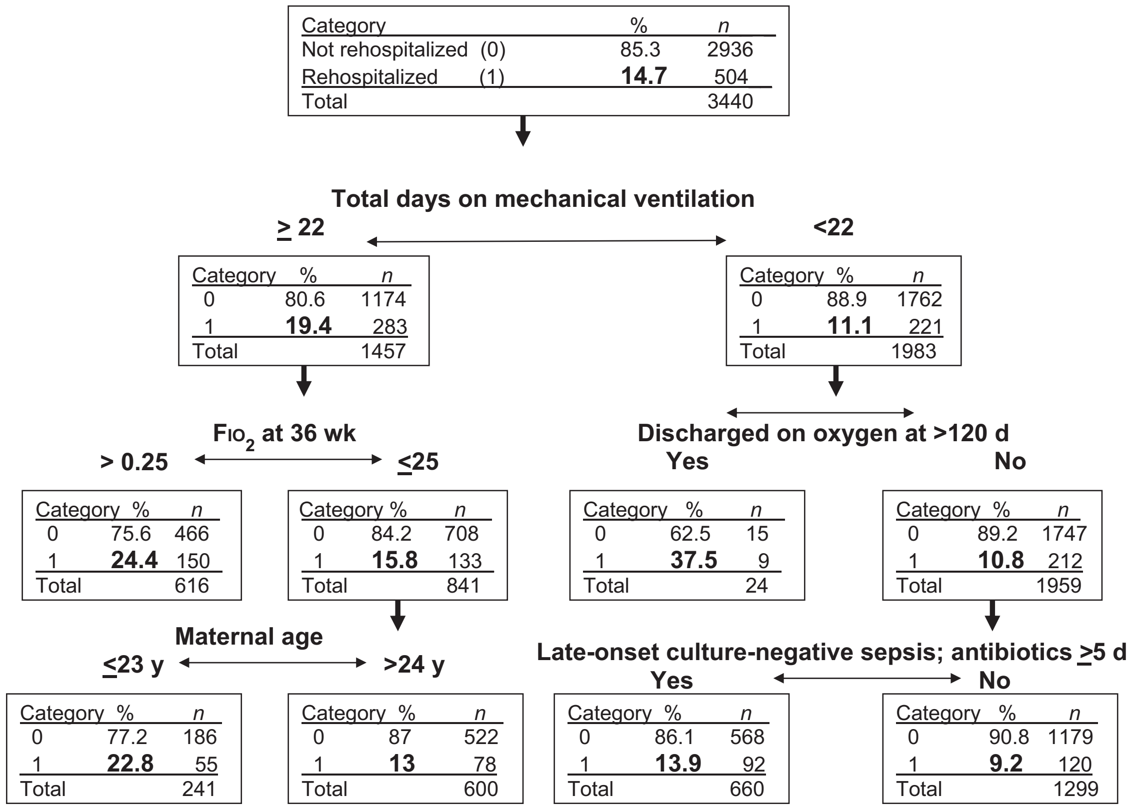

FIGURE 2

CART model for rehospitalizations that resulted from respiratory causes in the first year. In each node (rectangle), the category "0" or "1" refers to the absence or presence of respiratory rehospitalization, respectively, and the percentages and *n* values refer to the infants in each of the categories.

tem), total days on mechanical ventilation (CART model), and male gender (scoring system and CART model) were not surprising given their known relevance as markers of in-hospital morbidity as well as vulnerability to worse outcome (eg, male gender).[17–20]

Evaluation of the scoring system and CART model for respiratory rehospitalization in the first year revealed that most variables were not shared. This finding might be because the selection of variables by each method is different, with a bias toward selection of continuous variables (eg, days on ventilation, F_{IO_2}, maternal age) that can be evaluated for a threshold by using CART analysis. Conversely, the scoring system based on logistic regression chose primarily dichotomous (yes/no) variables (eg, discharge with bronchodilators, infant in hospital >120 days for pulmonary reasons, private insurance versus other). The common theme is that indicators of increased respiratory morbidity (scoring system: discharge with bronchodilators and infant in hospital for >120 days for pulmonary reasons; CART model: total days on mechanical ventilation and F_{IO_2} at 36 weeks) were associated with rehospitalization for respiratory illness in the first year. It is possible that there is an element of the "self-fulfilling prophecy" in this analysis, as infants with these indicators of respiratory morbidity might be subject to higher vigilance on the part of their caregiver or physicians and might be admitted to hospital more often. It is also worth noting that having had multiple episodes of late-onset culture-negative infection treated with antibiotics for ≥5 days was a risk factor by both regression and CART analyses. It is possible that these infants also had a higher risk of suspected or proven infections after discharge, which we speculate might be a result of variations in individual susceptibility or response to infections. Private insurance was associated with a lower risk of rehospitalization compared with nonprivate insurance (most often Medicaid). This finding has been observed before in a study of racial/ethnic disparities in rehospitalization of ELBW infants[21] and is considered to be a marker of relatively low socioeconomic status. We speculate that this might be a marker for a combination of different variables (eg, environmental pollutants, health care–related behaviors) which might increase the risk for respiratory rehospitalization.

The strengths of this study include the relatively large sample of ELBW infants recruited from multiple sites and prospective data-collection by trained observers. In addition, the scoring systems and CART models use relatively well-defined variables that are easy to collect and do not use arbitrary thresholds. The variables contribute to the conclusions on the basis of their actual predictive power (eg, the scoring system uses variables weighted in accordance with their independent contribution, and the CART model has the variables most closely associated with the outcome at the top of the tree, and the optimal thresholds are determined for each variable in the model). The model structures are evident, and they are simple to use.

One limitation of this study is that it sacrifices some improvement in predictive ability for generalizability. The models are not highly accurate, probably because variables such as center or geographic region that account for some of the variation in rehospitalization were not evaluated. Center differences in rates of BPD and BPD/death are well known, and it is possible that the magnitude of variation in respiratory sequelae after discharge might also vary among centers; evaluation of such center variation was beyond the scope of this study. However, the rates of rehospitalization in our study are roughly comparable to those from previous studies in the NICHD NRN,[21] as well as from other studies in the United States[4] and other developed countries.[3,22] The decision to admit an infant to the hospital is a physician decision, and although current practice is the use of best clinical judgment, variations in the criteria or thresholds for readmission might also vary across centers and even within centers by physician. A method that can be easily applied in the routine clinical setting should involve clinical data that are already available or data that can be easily obtained in most hospitals. This rules out lung function and polysomnography analyses, genomic/proteomic/metabolomic markers, and other sophisticated methods that might improve the ability to predict adverse outcome but are too expensive, difficult to do, labor intensive, or simply not available at most hospitals. However, predictive ability is usually good even when clinical variables are used alone.[23]

One potential limitation of this study is that participating centers are academic centers with a referral base and patient population distinct from smaller nonacademic centers. The differences in patient populations (and their associated characteristics such as insurance status) and clinical care practices make it difficult to extrapolate models to centers outside the NRN or in other countries. This issue can be overcome by evaluating these models in other centers or by development of region-specific models using similar methods. In addition, the completeness and accuracy of the rehospitalization data, as well as with the history of diuretics and bronchodilators, is not known because these data were collected by using patient history and not prospectively. A weakness of our study is the lack of complete follow-up and a substantial proportion of infants missing data for certain variables. However, these limitations are associated with most similar studies, and prospective data collection from office and clinic visits and a careful review of hospital records from rehospitalizations would be required to overcome these limitations.

CONCLUSIONS

The scoring systems and CART models enabled the identification of ELBW infants who are at higher risk of rehospitalization during infancy. These models might indicate the need for additional vigilance in care strategies after discharge such as respiratory syncytial virus immunoprophylaxis, day care infection control, and more frequent primary care visits. Further detailed analysis of rehospitalization data collected prospectively might yield additional insights into underlying reasons for the rehospitalization and possible preventive strategies.

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